



## INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

<b>(51) International Patent Classification <sup>5</sup> :</b> A61K 37/00, 37/02, C07K 5/00 C07K 7/00	<b>A1</b>	<b>(11) International Publication Number:</b> WO 92/19254 <b>(43) International Publication Date:</b> 12 November 1992 (12.11.92)
<b>(21) International Application Number:</b> PCT/US92/03119 <b>(22) International Filing Date:</b> 15 April 1992 (15.04.92)  <b>(30) Priority data:</b> 690,755                      24 April 1991 (24.04.91)      US 852,086                      20 March 1992 (20.03.92)      US  <b>(71) Applicant:</b> WARNER-LAMBERT COMPANY [US/US]; 2800 Plymouth Road, Ann Arbor, MI 48105 (US).  <b>(72) Inventors:</b> HORWELL, David, Christopher ; 8 West Hill, Foxton, Cambridge CB5 0HT (GB). HUGUES, John ; Stocks Barn East, Swaffram Prior, Cambridge CB5 0HT (GB). RICHARDSON, Reginald, Stewart ; 9 Rockall Close, Haverhill, Suffolk CB9 0LV (GB). HOWSON, William ; Brook Cottage, 46 Chapel Road, Weston Green, Weston Colville, Cambridge Shire (GB).		<b>(74) Agents:</b> ANDERSON, Elizabeth, M.; Warner-lambert Company, 2800 Plymouth Road, Ann Arbor, MI 48105 (US) et al.  <b>(81) Designated States:</b> AT (European patent), AU, BE (Euro- pean patent), CA, CH (European patent), DE (Euro- pean patent), DK (European patent), ES (European pa- tent), FR (European patent), GB (European patent), GR (European patent), IT (European patent), JP, LU (Euro- pean patent), MC (European patent), NL (European pa- tent), SE (European patent).  <b>Published</b> <i>With international search report.</i>
<b>(54) Title:</b> $\alpha$ -SUBSTITUTED POLYPEPTIDES HAVING THERAPEUTIC ACTIVITY  <b>(57) Abstract</b>  The compounds of the invention are $\alpha$ -substituted mono-, di-, tri-, tetra-, and pentapeptides useful in treating obesity, anxiety, gastrointestinal ulcers, pain, stroke, and inflammation. They are also useful in blocking the reaction caused by withdrawal from drug or alcohol use and in reducing gastric acid secretion. They are further useful as agents in hypertension, heart failure, stroke, cognition, memory enhancement, spasticity, depression, diabetes, cancer, asthma, bladder dysfunction, psychosis, and arthritis and/or inflammatory pain. Pharmaceutical compositions, novel intermediates, and processes are also included.		

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$\alpha$ -SUBSTITUTED POLYPEPTIDES  
HAVING THERAPEUTIC ACTIVITY

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## CROSS-REFERENCE TO RELATED APPLICATION

This application is a continuation-in-part application of United States Serial Number 07/690,755, filed April 24, 1991.

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## BACKGROUND OF THE INVENTION

Peptides form the main messenger systems within and between cells and they number more than a thousand. Over a hundred peptides are known to act as hormone, neurohormones, or neurotransmitters, and this number is growing rapidly. The potential for drug development is therefore vast. However, the great majority of peptide messengers are not suitable for use as pharmaceuticals in their natural state.

The problems of natural peptides as drugs are lack of oral activity, failure to penetrate the blood-brain barrier, rapidly metabolized, no selectivity for receptor subclasses, antigenic properties, and expensive to make.

The vast majority of small peptide messengers are not suitable as drugs, particularly where an orally administered and possibly centrally active drug is required. In this situation the development of modified peptides offer significant opportunities. The  $\alpha,\alpha$ -disubstituted amino acids are non-genetically coded synthetic analogues of natural mammalian  $\alpha$ -amino acids and are incorporated at least once into the neuropeptides of this patent.

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Some examples of therapeutic applications of these modified peptides (peptoids) are given in Table I below.

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TABLE I

	Endogenous Peptide	Peptoid Type*	Therapy
	Angiotensin	ANT	Hypertension Heart Failure
	Atrial Natriuretic Factor	AG	Heart Failure
10	Thyrotropin Releasing Factor	AG	Stroke Cognition Spasticity Depression
	Neuropeptide-Y	ANT	Hypertension Depression Obesity
	Glucagon	ANT	Diabetes
	Insulin	AG	Diabetes
15	Gastrin	ANT	Gastric Ulcer Cancer
	Bombesin	ANT	Cancer
	Tachykinins SP, NKA, NKB	ANT	Antipsychotic Analgesic Antiinflammatory Antiasthmatic

\* ANT = Antagonist; AG = Agonist

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These offer completely novel approaches to drug treatment. For example, all of the major tranquilizers block central dopaminergic function indiscriminately. An antipsychotic modified peptide designed to act through the mesolimbic CCK-neuropeptide/Dopamine system may be considerably more selective. An improvement in quality through the ability to modify drug resistant characteristics

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is also expected. In psychosis the blunting of affect leading to general impoverishment of social interactions with schizophrenics is expected to be susceptible to alternate modified peptide therapies.

5 The highly selective behavioral responses elicited by individual neuropeptides is shown in the Table II below.

10 **TABLE II**  
**Behavioral Responses to Peptides**

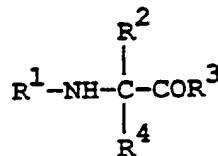
	Peptide	Behavior
	Angiotensin-II	Dipsogenesis
	Cholecystokinin	Cessation of Feeding Drowsiness Enhanced Memory
	Adrenocorticotrophic Hormone	Enhanced Alertness Enhanced Cognition
15	$\beta$ -Endorphin	Decreased Awareness Amnesia Reward Analgesia
	Dynorphin	Decreased Reward Drowsiness Analgesia
	Luteinizing Hormone Releasing Factor	Increased Sexual Receptivity
20	Corticotrophin Releasing Factor	Anxiety Enhanced Vigilance
	Thyrotropin Releasing Factor	Increased Activity Enhanced Awareness
	SP or NKA	A dopamine behavioral syndrome, i.e., increased locomotion, rearing
	SP	Antidipsogenic activity

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## SUMMARY OF THE INVENTION

The invention relates to novel compounds of formula



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and the pharmaceutically acceptable salts thereof wherein  $\text{R}^1$ ,  $\text{R}^2$ ,  $\text{R}^3$ , and  $\text{R}^4$  are as defined hereinbelow.

In commonly assigned copending application 07/609,754, filed on April 24, 1991, by Horwell, et al, the disclosure of which is incorporated by reference, CCK analogues containing  $\alpha, \alpha$ -disubstituted amino acids are disclosed.

The invention also relates to a pharmaceutical composition containing an effective amount of a compound according to formula I in combination with a pharmaceutically acceptable carrier in unit dosage form for appetite suppression. The invention also relates to a method for suppressing appetite in a mammal.

The compounds of the invention are also useful for blocking the reaction caused by withdrawal from drug or alcohol use. The compounds of the invention are also useful in reducing gastric acid secretion, in treating gastrointestinal ulcers, in treating pain, treating and/or preventing stroke, treating inflammation, and in treating anxiety.

The compounds of the invention are also useful in treating cognitive deficits, small cell lung cancer, colonic cancer, peptic ulcers, and are useful in contraception.

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The invention also relates to a pharmaceutical composition for reducing gastric acid secretion containing an effective amount of a compound of formula I in combination with a pharmaceutically acceptable carrier in unit dosage form effective for  
5 reducing gastric acid secretion.

The invention also relates to a method for reducing gastric acid secretion in mammals which comprises administering an amount effective for  
10 gastric acid secretion reduction of the composition described above to a mammal in need of such treatment.

The invention also relates to a pharmaceutical composition containing an effective amount of a  
15 compound of formula I in combination with a pharmaceutically acceptable carrier in unit dosage form effective for reducing anxiety.

The invention also relates to a method for reducing anxiety in mammals which comprises  
20 administering an amount effective for anxiety reduction of the composition described above to a mammal in need of such treatment.

The invention also relates to a pharmaceutical composition containing an effective amount of a  
25 compound of formula I in combination with a pharmaceutically acceptable carrier in unit dosage form effective for treating gastrointestinal ulcers.

The invention further relates to a method for treating gastrointestinal ulcers in mammals which  
30 comprises administering an amount effective for gastrointestinal ulcer treatment of the composition as described above to a mammal in need of such treatment.

The invention also relates to a pharmaceutical  
35 composition containing an effective amount of a

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compound of formula I in combination with a pharmaceutically acceptable carrier in unit dosage form effective for treating inflammation.

5 The invention further relates to a method for treating inflammation in mammals which comprises administering an amount effective of a composition as described above to a mammal in need of such treatment.

10 The invention also relates to a pharmaceutical composition for preventing the withdrawal response produced by chronic treatment or abuse of drugs or alcohol.

15 The invention further relates to a method for treating the withdrawal response produced by withdrawal from chronic treatment or withdrawal from abuse of drugs or alcohol. Such drugs include benzodiazepines, especially diazepam, cocaine, caffeine, opioids, alcohol, and nicotine. Withdrawal symptoms are treated by administration of an  
20 effective withdrawal treating amount of a compound of the instant invention.

This invention also relates to a pharmaceutical composition containing a therapeutically effective amount of a compound according to formula I in  
25 combination with a pharmaceutically acceptable carrier in unit dosage form for treating psychosis.

The invention also relates to a method for treating psychosis in mammals which comprises administering an amount effective for treatment of  
30 the composition described above to a mammal in need of such treatment.

This invention also relates to a pharmaceutical composition containing a therapeutically effective amount of a compound according to formula I in



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combination with a pharmaceutically acceptable carrier in unit dosage form for treating asthma.

5 The invention also relates to a method for treating asthma in mammals which comprises administering an amount effective for treatment of the composition described above to a mammal in need of such treatment.

10 This invention also relates to a pharmaceutical composition containing a therapeutically effective amount of a compound according to formula I in combination with a pharmaceutically acceptable carrier in unit dosage form for treating bladder dysfunction.

15 The invention also relates to a method for treating bladder dysfunction in mammals which comprises administering an amount effective for treatment of the composition described above to a mammal in need of such treatment.

20 This invention also relates to a pharmaceutical composition containing a therapeutically effective amount of a compound according to formula I in combination with a pharmaceutically acceptable carrier in unit dosage form for treating arthritis and/or inflammatory pain.

25 The invention also relates to a method for treating arthritis and/or inflammatory pain in mammals which comprises administering an amount effective for treatment of the composition described above to a mammal in need of such treatment.

30 The invention further relates to methods of treating hypertension, heart failure, stroke, cognition, memory enhancement, spasticity, depression, and diabetes.

35 The invention further provides processes for the preparation of compounds of formula I.

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The invention further provides novel intermediates useful in the preparation of compounds of formula I and also provides processes for the preparation of the intermediates.

5 The invention also relates to a pharmaceutical composition for treating pain and to a method of using a compound of formula I for treating pain.

10 The invention also relates to a pharmaceutical composition for treating and/or preventing stroke and to a method of using a compound of formula I for treating and/or preventing stroke.

#### DETAILED DESCRIPTION

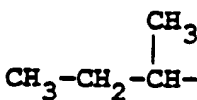
15 The following provides a dictionary of the terms used in the description of the invention.

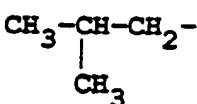
	<u>Abbreviation</u>	<u>Side Chain</u>	<u>Amino Acid</u>
	ALA	CH <sub>3</sub> -	Alanine
20	ARG	$\begin{array}{c} \text{NH} \\   \\ \text{NH}_2-\text{C}-\text{NH}-\text{CH}_2-\text{CH}_2-\text{CH}_2- \end{array}$	Arginine
	ASN	$\begin{array}{c} \text{O} \\   \\ \text{NH}_2-\text{C}-\text{CH}_2- \end{array}$	Asparagine
	ASP	HOOC-CH <sub>2</sub> -	Aspartic Acid
	CYS	HS-CH <sub>2</sub> -	Cysteine
	GLU	HOOC-CH <sub>2</sub> -CH <sub>2</sub> -	Glutamic Acid
25	GLN	$\begin{array}{c} \text{O} \\    \\ \text{NH}_2-\text{C}-\text{CH}_2-\text{CH}_2- \end{array}$	Glutamine

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<u>Abbreviation</u>	<u>Side Chain</u>	<u>Amino Acid</u>
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HIS		Histidine
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ILE		Isoleucine
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LEU		Leucine
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5	LYS	$\text{NH}_2\text{-CH}_2\text{-CH}_2\text{-CH}_2\text{-CH}_2\text{-CH}_2\text{-}$	Lysine
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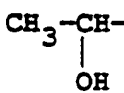
	MET	$\text{CH}_3\text{-S-CH}_2\text{-CH}_2\text{-}$	Methionine
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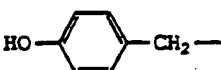
	PHE		Phenylalanine
--	-----	---	---------------

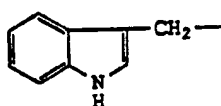
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	PRO		Proline
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	SER	$\text{HO-CH}_2\text{-}$	Serine
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	THR		Threonine
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	TYR		Tyrosine
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	TRP		Tryptophan
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<u>Abbreviation</u>	<u>Side Chain</u>	<u>Amino Acid</u>
VAL	$\begin{array}{c} \text{CH}_3 - \text{CH} - \\   \\ \text{CH}_3 \end{array}$	Valine

<u>Abbreviation</u>	<u>N-Terminal Protecting Group</u>	
5	H	Hydrogen
	BOC	<u>Tert</u> -butyloxy-carbonyl
	CBZ (or Z)	Benzyloxy-carbonyl
	IBU	Isobutyryl
10	IVA	Isovaleryl
	NVA	n-Valeryl
	1-Adoc	1-Adamantylloxy-carbonyl
	2-Adoc	2-Adamantylloxy-carbonyl
	Fmoc	9-Fluorenyl-methoxycarbonyl
15		

<u>Abbreviation</u>	<u>C-Terminal Substituent/ Side Chain Protecting Group</u>
-NH <sub>2</sub>	Amide
-OCH <sub>3</sub>	Methyl ester

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<u>Abbreviation</u>	<u>C-Terminal Substituent/ Side Chain Protecting Group</u>
$-\text{OCH}_2\text{Ph}$	Benzyl ester/ether
$-\text{OC}(\text{CH}_3)_3$	<u>Tert</u> -butyl ester/ether

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The term "N-terminal protecting" as used herein refers to those groups known to the art intended to protect the N-terminus of an amino acid or peptide or to protect an amino group against undesirable reactions during a synthetic procedure or to prevent the attack of exopeptidases on the compounds or to increase the solubility of the compounds and includes, but is not limited to, sulfonyl, acetyl, pivaloyl, t-butyloxycarbonyl (Boc), benzyloxycarbonyl (Cbz), benzoyl, or an L- or D-aminoacyl residue, which may itself be N-protected similarly.

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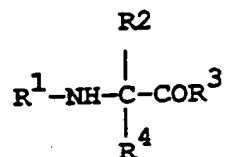
The term "C-terminal protecting group" as used herein refers to those groups known to the art intended to protect the C-terminus of an amino acid or peptide, these include but are not limited to an amide, methyl ester, benzyl ester/ether, tert-butyl ester/ether. Other examples of side chains and protecting groups are those known in the art. Any of those could be used.

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The compounds of the invention are represented by formula

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and the pharmaceutically acceptable salts thereof,  
wherein

- 10  $R^1$  is an N-terminal blocking group or from 0 to 4 amino acid residues or hydrogen;
- $R^2$  is a sidechain of a genetically coded amino acid except glycine;
- 15  $R^3$  is a C-terminal blocking group or from 0 to 4 amino acid residues, or  $-OH$ , or  $OR^n$  where  $R^n$  is straight or branched alkyl or cycloalkyl of 1 to 6 carbon atoms;
- $R^4$  is a sidechain of a genetically coded amino acid, except glycine, or
- 20  $-HC=CH_2$ ,
- $-C\equiv CH$ ,
- $-CH_2-CH=CH_2$ ,
- $-CH_2C\equiv CH$ ,
- $-CH_2Ar$ ,
- $-CH_2OR$ ,
- 25  $-CH_2OAr$ ,
- $-(CH_2)_nCO_2R$ ,
- $-(CH_2)_nNR^5R^6$  wherein n is an integer of from 0 to 3, R is hydrogen or lower alkyl, Ar is a mono- or polycyclic unsubstituted or substituted carbo- or heterocyclic aromatic or hydroaromatic moiety;
- 30 neither  $R^2$  nor  $R^4$  can be hydrogen;
- $R^1$  plus  $R^3$  cannot be greater than 4 amino acid residues in total.
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Preferred compounds of the invention are those  
of formula I selected from:

- Formyl-MeMet-Leu-Phe-Obzl,
- Formyl-Met-MeLeu-Phe-OBzl,
- 5 Formyl-Met-Leu-MePhe-OBzl,
- Ac-MeLeu-Leu-Arginal,
- Ac-Leu-MeLeu-Arginal,
- MeTyr-Arg,
- Tyr-MeArg,
- 10 MeTyr-Pro-Phe-Pro-NH<sub>2</sub>,
- Tyr-MePro-Phe-Pro-NH<sub>2</sub>,
- Tyr-Pro-MePhe-Pro-NH<sub>2</sub>,
- Tyr-Pro-Phe-MePro-NH<sub>2</sub>,
- Me-Arg-Lys-Asp-Val-Tyr,
- 15 Arg-MeLys-Asp-Val-Tyr,
- Arg-Lys-MeAsp-Val-Tyr,
- Arg-Lys-Asp-MeVal-Tyr,
- Arg-Lys-Asp-Val-MeTyr,
- MeArg-Lys-Glu-Val-Tyr,
- 20 Arg-MeLys-Glu-Val-Tyr,
- Arg-Lys-MeGlu-Val-Tyr,
- Arg-Lys-Glu-MeVal-Tyr,
- Arg-Lys-Glu-Val-MeTyr,
- MeAsp-Leu-Asp-Pro-Arg,
- 25 Asp-MeLeu-Asp-Pro-Arg,
- Asp-Leu-MeAsp-Pro-Arg,
- Asp-Leu-Asp-MePro-Arg,
- Asp-Leu-Asp-Pro-MeArg,
- MeLys-Trp-Lys,
- 30 Lys-MeTrp-Lys,
- Lys-Trp-MeLys,
- MePhe-Met-Arg-Phe-NH<sub>2</sub>,
- Phe-MeMet-Arg-Phe-NH<sub>2</sub>,
- Phe-Met-MeArg-Phe-NH<sub>2</sub>,
- 35 Phe-Met-Arg-MePhe-NH<sub>2</sub>,

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- MeGlp-His-Pro,  
Glp-MeHis-Pro,  
Glp-His-MePro,  
MeArg-Tyr-Leu-Pro-Thr,  
5 Arg-MeTyr-Leu-Pro-Thr,  
Arg-Tyr-MeLeu-ProThr,  
Arg-Tyr-Leu-MePro-Thr,  
Arg-Tyr-Leu-Pro-MeThr,  
MeThr-Lys-Pro-Arg,  
10 Thr-MeLys-Pro-Arg,  
Thr-Lys-MePro-Arg,  
Thr-Lys-Pro-MeArg,  
MeThr-Pro-Arg-Lys,  
Thr-MePro-Arg-Lys,  
15 Thr-Pro-MeArg-Lys,  
Thr-Pro-Arg-MeLys,  
MeThr-Val-Leu,  
Thr-MeVal-Leu, and  
Thr-Val-MeLeu.
- 20 More preferred compounds of the invention are  
those of formula I selected from:
- Me-Tyr-Gly-Gly-Phe-Met,  
MeTyr-Gly-Gly-Phe-Met-NH<sub>2</sub>,  
MeTyr-Gly-Gly-Phe-Leu-NH<sub>2</sub>,  
25 Tyr-Gly-Gly-MePhe-Met,  
Tyr-Gly-Gly-MePhe-Met-NH<sub>2</sub>,  
Tyr-Gly-Gly-MePhe-Leu-NH<sub>2</sub>,  
Tyr-Gly-Gly-Phe-MeMet,  
Tyr-Gly-Gly-Phe-MeMet-NH<sub>2</sub>,  
30 Tyr-Gly-Gly-Phe-MeLeu-NH<sub>2</sub>,  
Z-DMePhe-Phe-Gly,  
Z-DPhe-MePhe-Gly,  
MeArg-Pro-Tyr-Ile-Leu,  
Arg-MePro-Tyr-Ile-Leu,  
35 Arg-Pro-MeTyr-Ile-Leu,



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Arg-Pro-Tyr-MeIle-Leu,  
Arg-Pro-Tyr-Ile-MeLeu,  
MeLeu-Asp-Ile-Ile-Trp,  
Leu-MeAsp-Ile-Ile-Trp,  
5 Leu-Asp-MeIle-Ile-Trp,  
Leu-Asp-Ile-MeIle-Trp,  
Leu-Asp-Ile-Ile-MeTrp,  
MeGlu-Cys-Tyr-Phe,  
Glu-MeCys-Val-Tyr-Phe,  
10 Glu-Cys-MeVal-Tyr-Phe,  
Glu-Cys-Val-MeTyr-Phe, and  
Glu-Cys-Val-Tyr-MePhe.

Most preferred compounds of the invention are  
those of formula I selected from:

15 MeLys-Trp-Asp-Asn-Gln,  
Lys-MeTrp-Asp-Asn-Gln,  
Lys-Trp-MeAsp-Asn-Gln,  
Lys-Trp-Asp-MeAsn-Gln,  
Lys-Trp-Asp-Asn-MeGln,  
20 MeVal-Gly-His-Leu-Met-NH<sub>2</sub>,  
Val-Gly-MeHis-Leu-Met-NH<sub>2</sub>,  
Val-Gly-His-MeLeu-Met-NH<sub>2</sub>,  
Val-Gly-His-Leu-MeMet-NH<sub>2</sub>,  
MeGlp-His-Trp-Ser-Tyr,  
25 Glp-MeHis-Trp-Ser-Tyr,  
Glp-His-MeTrp-Ser-Tyr,  
Glp-His-Trp-MeSer-Tyr,  
Glp-His-Trp-Ser-MeTyr,  
Gly-MeLeu-Arg-Pro-Gly-NH<sub>2</sub>,  
30 Gly-Leu-MeArg-Pro-Gly-NH<sub>2</sub>,  
Gly-Leu-Arg-MePro-Gly-NH<sub>2</sub>,  
MeTyr-Pro-Ser-Lys-Pro,  
Tyr-MePro-Ser-Lys-Pro,  
Tyr-Pro-MeSer-Lys-Pro,  
35 Tyr-Pro-Ser-MeLys-Pro,

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- Tyr-Pro-Ser-Lys-MePro,  
 MeThr-Arg-Gln-Arg-Tyr-NH<sub>2</sub>,  
 Thr-MeArg-Gln-Arg-Tyr-NH<sub>2</sub>,  
 Thr-Arg-MeGln-Arg-Tyr-NH<sub>2</sub>,  
 5 Thr-Arg-Gln-MeArg-Tyr-NH<sub>2</sub>,  
 Thr-Arg-Gln-Arg-MeTyr-NH<sub>2</sub>,  
 Gly-MeTrp-Thr-Leu-Asn,  
 Gly-Trp-MeThr-Leu-Asn,  
 Gly-Trp-Thr-MeLeu-Asn,  
 10 Gly-Trp-Thr-Leu-MeAsn,  
 MeLeu-Tyr-Gly-Leu-Ala-NH<sub>2</sub>,  
 Leu-MeTyr-Gly-Leu-Ala-NH<sub>2</sub>,  
 Leu-Tyr-Gly-MeLeu-Ala-NH<sub>2</sub>,  
 Leu-Tyr-Gly-Leu-Aib-NH<sub>2</sub>,  
 15 MePhe-Phe-Trp-Lys-Thr,  
 Phe-MePhe-Trp-Lys-Thr,  
 Phe-Phe-MeTrp-Lys-Thr,  
 Phe-Phe-Trp-MeLys-Thr,  
 Phe-Phe-Trp-Lys-MeThr,  
 20 MePhe-Phe-Gly-Leu-Met-NH<sub>2</sub>,  
 Phe-MePhe-Gly-Leu-Met-NH<sub>2</sub>,  
 Phe-Phe-Gly-MeLeu-Met-NH<sub>2</sub>,  
 Phe-Phe-Gly-Leu-MeMet-NH<sub>2</sub>,  
 and the N<sup>α</sup>-4-hydroxyphenylacetyl derivatives and  
 25 the NH<sub>2</sub>-CO-(CH<sub>2</sub>)<sub>4</sub>-CO- derivatives of the above four  
 compounds,  
 N-[[ (4-Chlorophenyl)methoxy]carbonyl]-L-  
 tryptophyl-α-methyl-DL-phenylalaninamide,  
 N-[[[4-(Trifluoromethyl)phenyl]methoxy]-  
 30 carbonyl]-L-tryptophyl-α-methyl-DL-phenylalaninamide,  
 N-[[[1,1'-Biphenyl]-4-ylmethoxy]carbonyl]-  
 L-tryptophyl-α-methyl-DL-phenylalaninamide,  
 N-[(9-Anthracenylmethoxy)carbonyl]-L-tryptophyl-  
 α-methyl-DL-phenylalaninamide,

N-[(1-Naphthalenylmethoxy) carbonyl]-L-tryptophyl- $\alpha$ -methyl-DL-phenylalaninamide,

N-[(1-Naphthalenylmethoxy) carbonyl]-L-tryptophyl- $\alpha$ -methyl-L-phenylalaninamide,

5 N-[(1-Naphthalenylmethoxy) carbonyl]-L-tryptophyl- $\alpha$ -methyl-D-phenylalaninamide,

N-[[[4-(Propoxycarbonyl)phenyl]-methoxy] carbonyl]-L-tryptophyl- $\alpha$ -methyl-DL-phenylalaninamide,

10 N-[(Phenylmethoxy) carbonyl]-L-tryptophyl- $\alpha$ -methyl-DL-phenylalanylglycinamide,

N-[(1-Naphthalenylmethoxy) carbonyl]-L-tryptophyl- $\alpha$ -methyl-DL-phenylalanylglycinamide,

15 N-[(1-Naphthalenylmethoxy) carbonyl]-L-tryptophyl- $\alpha$ -methyl-L-phenylalanylglycinamide, and

N-[[[2,3-Dimethoxyphenyl)methoxy] carbonyl]-L-tryptophyl- $\alpha$ -methyl-DL-phenylalaninamide.

20 The compounds include solvates, hydrates, and pharmaceutically acceptable salts of the compounds of formula I above.

The compounds of the present invention may exist as diastereomers, mixtures of diastereomers, or as the mixed or the individual optical enantiomers. The present invention contemplates all such forms of the compounds. The mixtures of diastereomers are typically obtained as a result of the reactions described more fully below. Individual diastereomers may be separated from mixtures of the diastereomers by conventional techniques such as column chromatography or repetitive recrystallizations. Individual enantiomers may be separated by conventional methods well known in the art such as conversion to a salt with an optically active compound, followed by separation by chromatography or

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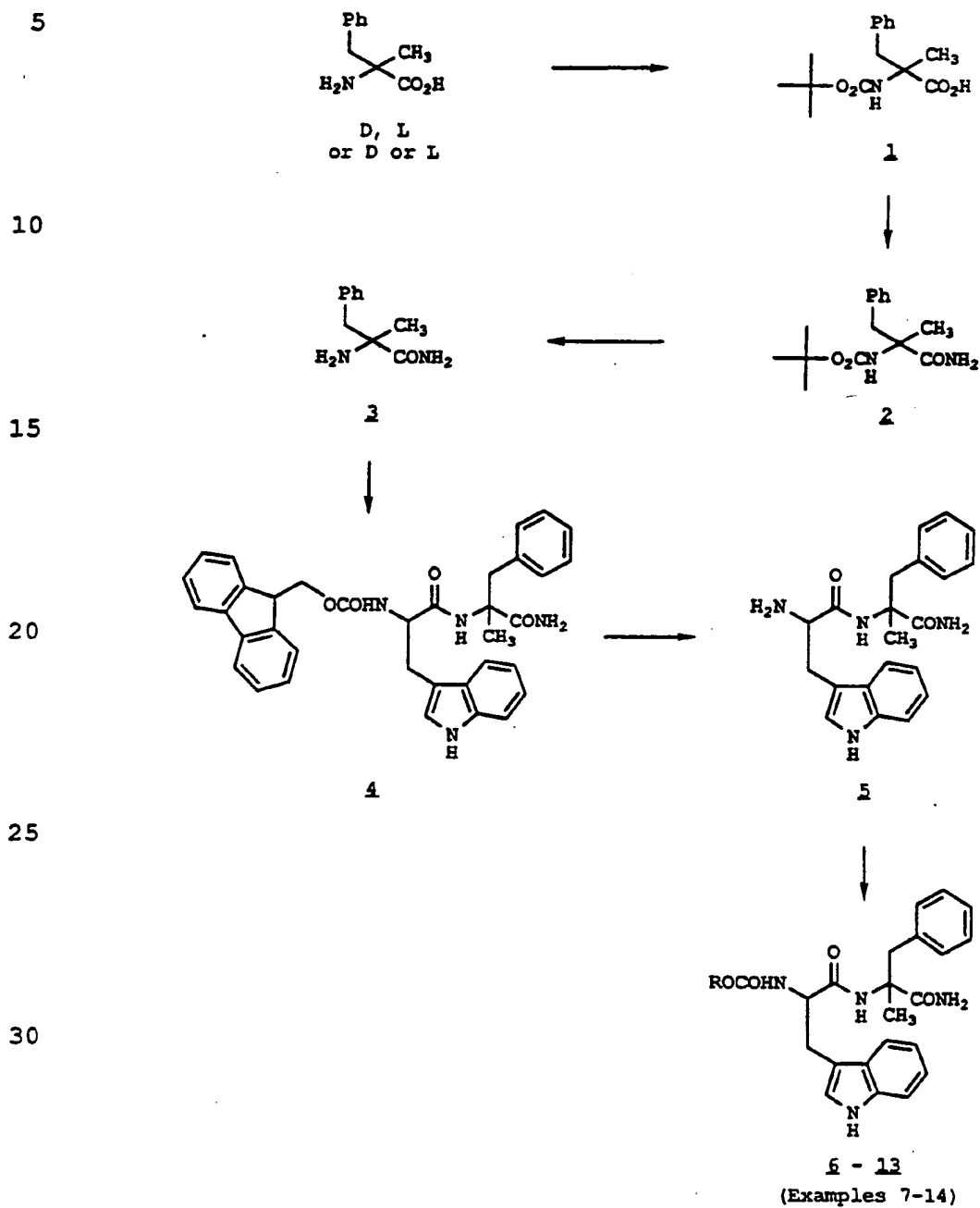
-18-

r crystallization and r conversion to the nonsalt form.

5 The compounds of the present invention may be formed by coupling individual substituted  $\alpha$ -amino acids by methods well known in the art. (See, for example, standard synthetic methods discussed in the multi-volume treatise The Peptides, Analysis, Synthesis, Biology, by Gross and Meienhofer, Academic Press, New York). If known, the individual  
10 substituted alpha amino acid starting materials are synthesized by methods within the skill of the art. (Synthesized racemic [DL]- $\alpha$ -methyl tryptophan methyl ester - see Braña, M. F., et al, J. Heterocyclic Chem., 1980.

15 In Scheme I below, the  $\alpha$ -MePhe was N-terminally protected with (BOC)<sub>2</sub>O to afford BOC  $\alpha$ -MePhe. (1) Compound 1 was then activated with DCCI and HOBT and reacted with NH<sub>3</sub>(g) to give the amide. (2) Removal of the BOC group with TFA gave the amine (3), which was  
20 reacted with FMOC-L-TrpOPfp to afford the dipeptide. (4) A further deprotection with piperidine in DMF gave the amine (5), which was reacted with the appropriate chloroformate to give the Examples 7 through 14. (6-13)

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SCHEME 1  
(Examples 2-13)

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In Scheme 2 below, Compound 1 was activated with DCCI and HODhbt to give 14, which was reacted with CTlyNH<sub>2</sub> in EtOAc to afford the N-protected dipeptide. (15) Removal of the BOC group with TFA gave the amine (16), which was reacted with ROCO(L) Trp activated with HBTU to give the Examples 18 and 19. (17,18)

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21  
SCHEME 2

(Examples 2, 14, and 16-19)

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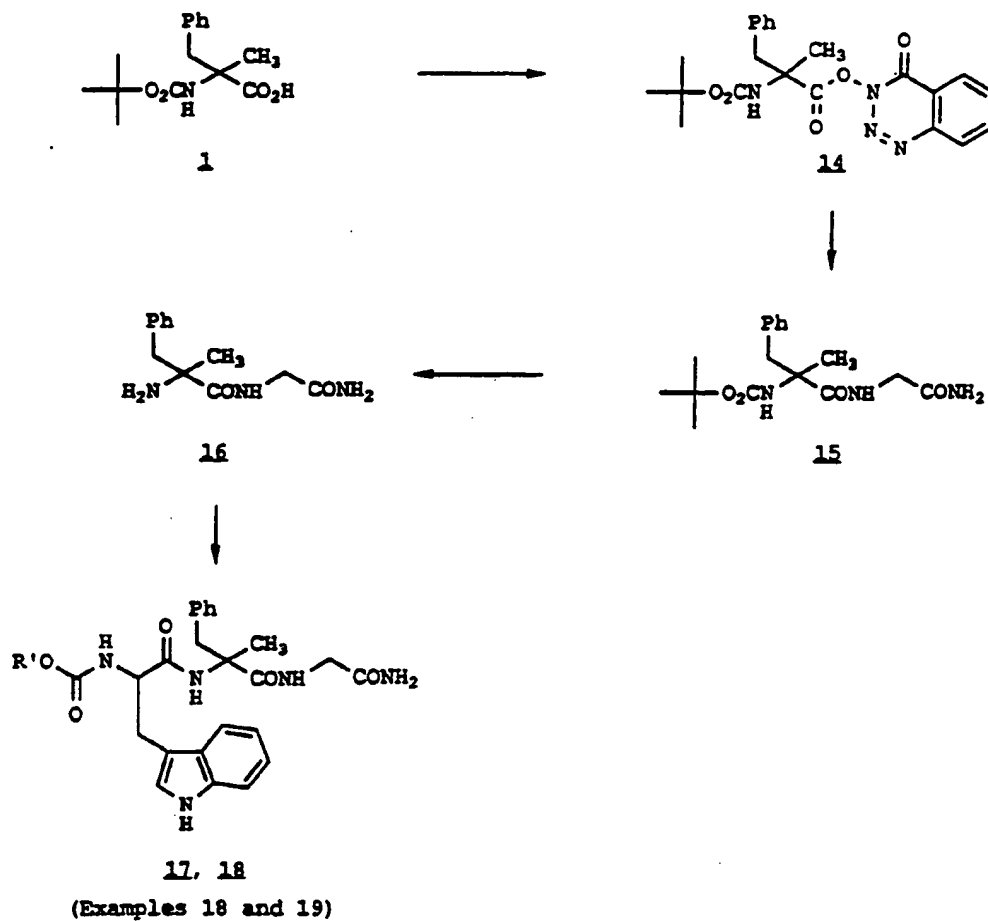
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For preparing pharmaceutical compositions from the compounds of this invention, inert, pharmaceutically acceptable carriers can be either solid or liquid. Solid form preparations include powders, tablets, dispersible granules, capsules, cachets, and suppositories.

A solid carrier can be one or more substances which may also act as diluents, flavoring agents, solubilizers, lubricants, suspending agents, binders, or tablet disintegrating agents; it can also be an encapsulating material.

In powders, the carrier is a finely divided solid which is in a mixture with the finely divided active component. In tablets, the active component is mixed with the carrier having the necessary binding properties in suitable proportions and compacted in the shape and size desired.

For preparing suppository preparations, a low-melting wax such as a mixture of fatty acid glycerides and cocoa butter is first melted and the active ingredient is dispersed therein by, for example, stirring. The molten homogeneous mixture is then poured into convenient sized molds and allowed to cool and solidify.

The powders and tablets preferably contain 5% to about 70% of the active component. Suitable carriers are magnesium carbonate, magnesium stearate, talc, lactose, sugar, pectin, dextrin, starch, tragacanth, methyl cellulose, sodium carboxymethyl cellulose, a low-melting wax, cocoa butter, and the like.

The term "preparation" is intended to include the formulation of the active component with encapsulating material as a carrier providing a capsule in which the active component (with or without other carriers) is surrounded by a carrier



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which is thus in association with it. Similarly, cachets are included.

Tablets, powders, cachets, and capsules can be used as solid dosage forms suitable for oral administration.

5           Liquid form preparations include solutions, suspensions, and emulsions. Sterile water or water-propylene glycol solutions of the active compounds may be mentioned as an example of liquid preparations suitable for parenteral administration.  
10          Liquid preparations can also be formulated in solution in aqueous polyethylene glycol solution.

          Aqueous solutions for oral administration can be prepared by dissolving the active component in water  
15          and adding suitable colorants, flavoring agents, stabilizers, and thickening agents as desired. Aqueous suspensions for oral use can be made by dispersing the finely divided active component in water together with a viscous material such as  
20          natural synthetic gums, resins, methyl cellulose, sodium carboxymethyl cellulose, and other suspending agents known to the pharmaceutical formulation art.

          Preferably the pharmaceutical preparation is in unit dosage form. In such form, the preparation is  
25          in unit dosage form. In such form, the preparation is divided into unit doses containing appropriate quantities of the active component. The unit dosage form can be a packaged preparation, the package containing discrete quantities of the preparation,  
30          for example, packeted tablets, capsules, and powders in vials or ampoules. The unit dosage form can also be a capsules, cachet, or tablet itself, or it can be the appropriate number of any of these packaged forms.

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Some of the peptides of the invention were constructed on solid-phase resins designed to produce C-terminal amides either by treatment of the resin with ammonia in methanol or by direct cleavage of an appropriately substituted resin using trifluoroacetic acid, with the required scavengers, giving the amides directly. The latter protocol was used with DuPont RapidAmide® or Nova Biochem Ultrasyn C® resins either in a simple bubbler apparatus (DuPont resin) or automated synthesizer (Nova Biochem resin).

Using a Pharmacia 4170 automated peptide synthesizer and Bioplus® software the peptides were constructed from the C-terminus using Fmoc amino acid pentafluorophenyl or DEBt esters and HOBt catalysis. Each residue was present in a fivefold excess to ensure rapid and complete acylation. On a 0.095 mmol scale the peptide was isolated following TFA cleavage (94% TFA, 5% anisole, 1% ethanedithiol) from the resin (2 hours, room temperature).

The two isomers were separated by RP-HPLC (250 x 25 mm column, gradient elution, Solvent A 0.1% aqueous TFA, Solvent B 0.1% FFA in MeCN, gradient 20% to 80% B over 20 minutes. The peptides of the invention can be made by the above method. Although any compatible resin may be used or, alternatively, solution phase synthesis may be used.

Such peptides include but are not limited to the short chemotactic peptides, for example, formyl-Met-Leu-Phe-OBz, Met-enkephalin, enkephalinamides, leupeptin (Ac-Leu-Leu-Arginol), Kyotorphin (Tyr-Arg), Morphiceptin (Tyr-Pro-Phe-Pro-NH<sub>2</sub>), Thymopoetin II (Arg-Lys-Asp-Val-Tyr), Splenopentin (Arg-Lys-Glu-Val-Tyr), Hamburger pentapeptide (Asp-Leu-Asp-Pro-Arg), virus replication inhibiting

peptide (Z-DPhe-Phe-Gly), DNA binding peptide (Lys-Trp-Lys), Molluscan cardioexcitatory peptide (Ph -Met-Arg-Phe-NH<sub>2</sub> and all FMRF-amide analogues), TRH (pGlu-His-Pro), Proctolin (Arg-Tyr-Leu-Pro-Thr),  
5 Tuftsin, (Thr-Lys-Pro-Arg), Kentsin (Thr-Pro-Arg-Lys), schizophrenia-related peptide (Tnr-Val-Leu) and short polypeptides or 5-residues or less which are fragments of longer peptides.

Preferred compounds are:

10 LTyr-Gly-Gly- $\alpha$ -MePhe-LLeu (isomer 1) and  
LTyr-Gly-Gly- $\alpha$ -MePhe-LLeu (isomer 2) whose full chemical names are N-[ $\alpha$ -methyl-N-[N-(N-L-tyrosylglycyl)glycyl]-L-phenylalanyl]-L-leucine trifluoroacetate (1:1 salt) and N-[ $\alpha$ -methyl-N-[N-(N-  
15 L-tyrosylglycyl)glycyl]-D-phenylalanyl]-L-leucine trifluoroacetate (1:1 salt).

Some of the compounds were evaluated in three tachykinin binding assays:

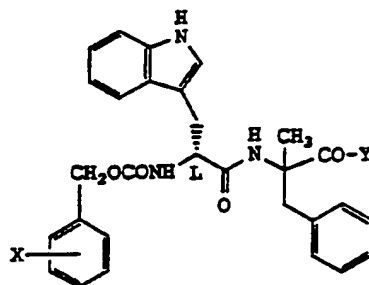
For the NK<sub>1</sub> receptor - measurement of the  
20 binding of [<sup>125</sup>I]-Bolton Hunter labeled substance P (0.1 nM) to guinea pig cerebral cortex membranes, and for the NK<sub>3</sub> receptor - measurement of the binding of [<sup>3</sup>H]-senktide (2 nM) to guinea pig cerebral cortex membranes. See Lee, C. M., et al, Eur. J. Pharmacol.  
25 130:209 (1986), and Guard, S., et al, Brit. J. Pharmacol. 99:767 (1990).

For the NK<sub>2</sub> receptor - measurement of the  
binding of [<sup>125</sup>I]-iodohistidyl neurokinin A (0.1 nM) to hamster urinary bladder membranes. See Buck and  
30 Shatzer, Life Sci. 42:2701 (1988).

TABLE III. Structure of Results

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Ex.	X	Y	Stereo-chemistry at $\alpha$ -Me-Phe	Binding IC50 (nM)		
				NK <sub>1</sub>	NK <sub>2</sub>	NK <sub>3</sub>
7	4-CL	NH <sub>2</sub>	D,L	>10 <sup>5</sup>	98	>10 <sup>5</sup>
8	4-CF <sub>3</sub>	NH <sub>2</sub>	D,L	>10 <sup>5</sup>	188	>10 <sup>5</sup>
9	4-Ph	NH <sub>2</sub>	D,L	>10 <sup>5</sup>	94	>10 <sup>5</sup>
10		NH <sub>2</sub>	D,L	>10 <sup>5</sup>	68	>10 <sup>5</sup>
11		NH <sub>2</sub>	D,L	>10 <sup>5</sup>	73	>10 <sup>5</sup>
12		NH <sub>2</sub>	L	~10 <sup>5</sup>	48	>10 <sup>5</sup>
13		NH <sub>2</sub>	D	>10 <sup>5</sup>	1850	>10 <sup>5</sup>
14	4-CO <sub>2</sub> -n-Pr	NH <sub>2</sub>	D,L	>10 <sup>5</sup>	144	>10 <sup>5</sup>
18	H	NHCH <sub>2</sub> CONH <sub>2</sub>	D,L	~10 <sup>5</sup>	20	>10 <sup>5</sup>
19		NHCH <sub>2</sub> CONH <sub>2</sub>	D,L	>10 <sup>5</sup>	14	>10 <sup>5</sup>
20		NHCH <sub>2</sub> CONH <sub>2</sub>	L	~10 <sup>5</sup>	6	>10 <sup>5</sup>
21	2,3-di-OCH <sub>3</sub>	NH <sub>2</sub>	D,L	2900	45	>10 <sup>5</sup>

The data in Table III show that the compounds are selective NK<sub>2</sub> receptor ligands. The compounds of Examples 18 and 19 illustrate NK<sub>2</sub> receptor antagonism. See Table IV. Therefore, they are expected to be useful in treating disorders mediated by tachykinins, e.g., respiratory disorders, inflammation, gastrointestinal disorders, ophthalmic diseases, allergies, pain, circulatory insufficiency, diseases of the central nervous system, and migraine.

NK<sub>2</sub> Functional Data Summary

Tissue	Agonist	Antagonist	Conc.	Dose/ ratio	pKa
Rat Colon	Eleodisin	Example 18	1 $\mu$ M	3.1	6.5
		Example 19	1 $\mu$ M	7.7	6.8
		L659,874	10 $\mu$ M	10.3	7.0
Hamster Bladder Urinary	NKA	Example 18	3 $\mu$ M	30	7.0
		Example 19	3 $\mu$ M	29	6.9
		L659,874	3 $\mu$ M	29	6.9
Hamster Trachea	NKA	Example 18	1 $\mu$ M	11	6.9
		Example 18	3 $\mu$ M	46	7.2
		Example 19	3 $\mu$ M	31	6.9
		Example 19	10 $\mu$ M	472	7.2
		L659,874	1 $\mu$ M	11	7.0
		L659,874	3 $\mu$ M	41	7.1

\* L659,874 is a standard NK<sub>2</sub> antagonist. Its chemical name is Glycinamide, N-acetyl-L-leucyl-L-methionyl-L-glutamyl-L-tryptophyl-L-phenylalanyl-Ac-LLeu-LMet-LGln-LTrp-LPhe-Gly-NH<sub>2</sub>

For the hamster trachea, see Maggi, C. A., Patacchini, R., Rovero, P., and Meri, A. Eur. J. Pharmacol., 1989;166:435-440.

For the hamster urinary bladder, see Mizrahi, J., Dion, S., D'Orleans-Juste, P., Escher, B., Drapeau, G., and Regoli, D., Eur. J. Pharmacol., 1985;118:25-36.

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For the rat colon, see Bailey, S. J. and Jordan, C. C., Br. J. Pharmacol., 1984;82:441-451.

The following examples illustrate the instant invention but are not intended to limit it in any way.

## EXAMPLE 1

Tyr-Gly-Gly-OMePhe-Leu

The peptide was prepared and separated as described above, using solid-phase methodology.

Isomer 1 (L,D,L or L,L,L), LTyr-Gly-Gly-OMePhe-LLeu  
NMR (D<sub>2</sub>O)  $\delta$  0.89 (6H, br d), 1.41 (3H, s), 1.57 (3H, br m), 3.18 (2H, 2bq), 3.12 (2H, d), 3.92 (4H, m), 4.25 (2H, m), 6.88 (2H, d), 7.18 (4H, d), 7.46 (3H, m). FAB-MS 57C (M+H)<sup>+</sup>, 592 (M+Na)<sup>+</sup>, 608 (M+K)<sup>+</sup>.

Isomer 2 (L,L,L or L,D,L) LTyr-Gly-Gly-OMePhe-LLeu  
NMR (D<sub>2</sub>O)  $\delta$  0.88 (6H, dd), 1.43 (3H, s), 1.57 (3H, br m), 3.20 (4H, m), 3.91 (4H, m), 4.23 (2H, m), 6.88 (2H, d), 7.16 (4H, d), 7.33 (3H, m). FAB-MS 570 (M+H)<sup>+</sup>, 592 (M+Na)<sup>+</sup>, 608 (M+K)<sup>+</sup>.

## EXAMPLE 2

N-(t-Butyloxycarbonyl)-DL- $\alpha$ -methylphenylalanine (1)

DL- $\alpha$ -Methylphenylalanine (5.0 g, 28 mmol) was dissolved in warm 10% Na<sub>2</sub>CO<sub>3</sub> solution (60 mL) and then cooled to 0°C. t-Butyloxycarbonyl anhydride (6.39 g, 29.3 mmol) in dioxan (50 mL) was added dropwise and the mixture stirred at 0°C for 1 hour. The mixture was then allowed to warm to room temperature and stirred for a further 24 hours. The solvents were then distilled off in vacuo and the residue taken up in H<sub>2</sub>O. This was then washed with CH<sub>2</sub>Cl<sub>2</sub> (3x), acidified with citric acid, and

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extracted with  $\text{CH}_2\text{Cl}_2$  (3x). The organic extracts were combined, dried ( $\text{MgSO}_4$ ), and the solvent distilled off in vacuo to give 1 as a white solid (6.2 g, 25.1 mmol, 90%):  $^1\text{H}$  NMR ( $\text{DMSO}-d_6$ )  $\delta$  1.18 (3H, s), 1.41 (9H, s), 2.91 (1H, d,  $J$  13 Hz), 3.31 (1H, d,  $J$  13 Hz), 6.71 (1H, bs), 7.09 (2H, d), 7.25 (3H m), 12.50 (1H, bs).

## EXAMPLE 3

10 N-(t-Butyloxycarbonyl)-DL- $\alpha$ -methylphenylalaninamide  
(2)

1 (6.7 g, 22 mmol) was dissolved in  $\text{CH}_2\text{Cl}_2$  (80 mL) and 1,3-dicyclohexylcarbodiimide (4.9 g, 24 mmol) followed by 1-hydroxybenzotriazole monohydrate (3.9 g, 28.8 mmol) added and the mixture stirred for 0.5 hour at room temperature. DMF (15 mL) was then added, the solution cooled to  $-10^\circ\text{C}$  and a slow stream of  $\text{NH}_3$  (g) bubbled through. The mixture thickened almost immediately so a further amount of DMF (50 mL) was added. After 0.5 hour, the addition of  $\text{NH}_3$  (g) was stopped and the white precipitate removed by filtration and washed with EtOAc. The washings were combined with the filtrate and the solvent distilled off in vacuo. The residue was partitioned between  $\text{H}_2\text{O}$  (500 mL) and  $\text{CH}_2\text{Cl}_2$ . The aqueous layer was washed with  $\text{CHCl}_3$  (3x), the organic extracts combined, washed with a saturated  $\text{NaHCO}_3$  solution, dried ( $\text{MgSO}_4$ ), and the solvent distilled off in vacuo. The white solid obtained was further purified by flash column chromatography on silica, eluting with a mixture of  $\text{CHCl}_3$ :MeOH (95:5) to give 2 as a white solid (4.4 g, 15.8 mmol, 66%):  $^1\text{H}$  NMR ( $\text{DMSO}-d_6$ )  $\delta$  1.33 (3H, s), 1.41 (9H, s), 3.31 (2H, bs), 6.25 (1H, bs), 7.15 (6H, m), 7.41 (1H, bs).

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## EXAMPLE 4

DL- $\alpha$ -Methylphenylalaninamide (3)

2 (4.4 g, 15 mmol) was stirred in TFA (15 mL) at room temperature for 15 minutes. The TFA was  
5 distilled off in vacuo and the residue taken up in EtOAc. The organic solution was carefully washed with saturated NaHCO<sub>3</sub> solution, dried (MgSO<sub>4</sub>), and the solvent removed in vacuo to give 3 as a white  
solid (1.9 g, 12.1 mmol, 70%) <sup>1</sup>H NMR (MeOH-d<sub>4</sub>)  $\delta$  1.40  
10 (3H, s), 2.77 (1H, d,  $\underline{J}$  13 Hz), 3.21 (1H, d,  $\underline{J}$  13 Hz), 7.30 (5H, m).

## EXAMPLE 5

15 N-(9H-Fluoren-9-ylmethoxy)carbonyl]-L-tryptophyl-DL- $\alpha$ -methylphenylalaninamide (4)

3 (1.8 g, 10.1 mmol) and N-[(9H-fluoren-9-ylmethoxy)carbonyl]-L-tryptophan pentafluorophenyl ester (6.0 g, 10.1 mmol) were stirred together in DMF  
20 (50 mL) at room temperature for 18 hours. The solution was concentrated in vacuo and H<sub>2</sub>O (400 mL) added. The aqueous suspension was extracted with EtOAc (3x) and the organic extracts combined, dried (MgSO<sub>4</sub>) and the solvent removed in vacuo to give crude 4.

25

## EXAMPLE 6

L-Tryptophyl-DL- $\alpha$ -methylphenylalaninamide (5)

4 (3.65 g, 6.2 mmol) was dissolved in a 20% solution of piperidine in DMF (20 mL) and stirred at  
30 room temperature for 20 minutes. The mixture was then concentrated in vacuo and H<sub>2</sub>O (400 mL) added; the white precipitate formed was then removed by filtration. Citric acid was added to the filtrate to pH 3 and washed with EtOAc (3x). The aqueous layer  
35 was made alkaline (pH 9) with solid Na<sub>2</sub>CO<sub>3</sub> and



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extracted with EtOAc (3x). The organic extracts were combined, dried ( $\text{MgSO}_4$ ) and the solvent removed in vacuo to give 5 as a pale yellow solid (2.2 g). Purification by flash column chromatography on silica, eluting with  $\text{CH}_2\text{Cl}_2$ :MeOH (10:1) gave the product 5 as a white foam (1.8 g, 4.93 mmol, 80%):  $^1\text{H}$  NMR ( $\text{DMSO}-d_6$ )  $\delta$  1.45 (0.5 x 3H, s), 1.51 (0.5 x 3H, s), 1.81 (2H, bs), 2.59 (0.5 x H, dd,  $J$  10.14 Hz), 2.76 (0.5 x H, dd,  $J$  9, 14 Hz), 3.15 (2H, m), 3.45 (2H, m), 6.95-7.60 (12H, m), 8.16 (0.5 x H, s), 8.28 (0.5 x H, s), 10.85 (1H, s).

## EXAMPLE 7

15 N-[[[4-Chlorophenyl)methoxy]carbonyl]-L-tryptophyl-  
 $\alpha$ -methyl-DL-phenylalaninamide (6)

Pyridine (0.11 mL, 1.4 mmol) was added dropwise to a stirred solution of 4-chlorobenzyl alcohol (0.20 g, 1.4 mmol) and triphosgene (0.15 g, 0.51 mmol) in  $\text{CH}_2\text{Cl}_2$  (5 mL) at  $0^\circ\text{C}$  and stirred for 5 minutes. The solvent was removed in vacuo and the resulting oil triturated with  $\text{Et}_2\text{O}$  and filtered. The filtrate was added to a solution of 5 (0.26 g, 0.71 mmol) and triethylamine (0.10 mL, 0.71 mmol) in THF (25 mL) and stirred overnight. The solvent was removed in vacuo to give a white solid which was partitioned between EtOAc and 10% citric acid solution. The organic layer was washed with saturated  $\text{NaHCO}_3$  solution and  $\text{H}_2\text{O}$  and dried ( $\text{MgSO}_4$ ). Further purification by flash column chromatography on silica eluting with a mixture of  $\text{CH}_2\text{Cl}_2$ :MeOH (95:5) gave 6 as a white foam (0.23 g, 0.43 mmol, 61%); mp  $89-101.3^\circ\text{C}$ ; MS (FAB)  $m/e$  533  $[\text{M}+\text{H}]$ :  $^1\text{H}$  NMR ( $\text{DMSO}-d_6$ )  $\delta$  1.38 (0.5 x 3H, s,  $\alpha\text{-CH}_3$ ), 1.40 (0.5 x 3H, s,  $\alpha\text{-CH}_3$ ), 2.80-3.40 (4H, m,  $\text{CH}_2\text{-indole}$ ,  $\text{CH}_2\text{Ph}$ ), 4.10-4.32 (1H, m, Trp  $\alpha\text{-H}$ ), 4.80-4.99 (2H, m,

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CH<sub>2</sub>O), 6.90-7.78 (18H, m, Ar, CONH<sub>2</sub>, CONH, OCONH),  
10.70 (1H, s, indole NH); Anal. (C<sub>29</sub>H<sub>29</sub>N<sub>4</sub>O<sub>4</sub>·0.3 H<sub>2</sub>O)  
C, H, N.

5

## EXAMPLE 8

N-[[[4-(Trifluoromethyl)phenyl]methoxy]carbonyl]-  
L-tryptophyl-α-methyl-DL-phenylalaninamide (7)

Prepared by the same method as 6. White foam  
(0.092 g, 62%); mp 91-112°C; MS (FAB) m/e 567 [M+H];  
10 <sup>1</sup>H NMR (DMSO-d<sub>6</sub>) δ 1.38 (0.5 x 3H, s, α-CH<sub>3</sub>), 1.41  
(0.5 x 3H, s, α-CH<sub>3</sub>), 2.70, 3.46 (4H, m, CH<sub>2</sub>-indole,  
CH<sub>2</sub>Ph), 4.12-4.36 (1H, m, Trp α-H), 4.90-5.16 (2H, m,  
CH<sub>2</sub>O), 6.90-7.88 (18H, m, Ar, CONH<sub>2</sub>, CONH, OCONH),  
10.84 (1H, s, indole NH); Anal. (C<sub>30</sub>H<sub>29</sub>N<sub>4</sub>O<sub>4</sub>F<sub>3</sub>·  
15 0.75 H<sub>2</sub>O) C, H, N.

## EXAMPLE 9

N-[[[1,1'-Biphenyl]-4-ylmethoxy]carbonyl]-L-  
tryptophyl-α-methyl-DL-phenylalaninamide (8)

Prepared by the same method as 6. White foam  
(0.050 g, 32%); mp 92-102°C; MS (FAB) m/e 576 [M+H];  
20 <sup>1</sup>H NMR (DMSO-d<sub>6</sub>) δ 1.38 (0.5 x 3H, s, α-CH<sub>3</sub>), 1.39  
(0.5 x 3H, s, α-CH<sub>3</sub>), 2.72-3.40 (4H, m, CH<sub>2</sub>-indole,  
CH<sub>2</sub>Ph), 4.12-4.35 (1H, m, Trp α-H), 4.90-5.08 (2H, m,  
25 CH<sub>2</sub>O), 6.92-7.85 (23H, m, Ar, CONH<sub>2</sub>, CONH, OCONH),  
10.90 (1H, s, indole NH); Anal. (C<sub>35</sub>H<sub>34</sub>N<sub>4</sub>O<sub>4</sub>·0.75 H<sub>2</sub>O)  
C, H, N.

## EXAMPLE 10

30 N-[(9-Anthracenylmethoxy)carbonyl]-L-tryptophyl-α-  
methyl-DL-phenylalaninamide (9)

Prepared by the same method as 6. Yellow foam  
(0.10 g, 23%); mp 113-130°C; MS (FAB) m/e 599 [M+H];  
35 <sup>1</sup>H NMR (DMSO-d<sub>6</sub>) 1.36 (3H, s, α-CH<sub>3</sub>), 2.25-3.20 (2H,  
m, CH<sub>2</sub>-indole), 3.25-3.40 (2H, m, CH<sub>2</sub>Ph), 4.20-4.38

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(1H, m, Trp  $\alpha$ -H), 5.95 (0.5 x 2H, AB,  $J$  12 Hz, CH<sub>2</sub>Ar), 6.01 (0.5 x 2H, AB,  $J$  12 Hz, CH<sub>2</sub>Ar), 6.85-7.20 (17H, m, Ar, CONH<sub>2</sub>, OCONH), 7.77 (0.5 x H, s, CONH), 7.83 (0.5 x H, s, CONH), 8.10 (1H, s, Ar), 8.13 (1H, s, Ar), 8.28 (1H, s, Ar), 8.31 (1H, s, Ar), 8.67 (1H, s, Ar), 10.80 (1H, s, indole NH); Anal. (C<sub>37</sub>H<sub>34</sub>N<sub>4</sub>O<sub>4</sub>·0.7 H<sub>2</sub>O) C, H, N.

## EXAMPLE 11

10 N-[(1-Naphthalenylmethoxy)carbonyl]-L-tryptophyl- $\alpha$ -methyl-DL-phenylalaninamide (10)

Prepared by the same method as 6. White foam (0.13 g, 34%); mp 102-113°C; MS (FAB) m/e 549 [M+H]; <sup>1</sup>H NMR (DMSO-d<sub>6</sub>)  $\delta$  1.40 (3H, s), 2.87 (1H, m), 3.05-3.45 (3H, m), 4.15-4.40 (1H, m), 5.30-5.50 (2H, m), 6.90-8.00 (21H, m), 10.70 (1H, s); Anal. (C<sub>33</sub>H<sub>32</sub>N<sub>4</sub>O<sub>4</sub>·0.4 H<sub>2</sub>O) C, H, N.

## EXAMPLE 12

20 N-[(1-Naphthalenylmethoxy)carbonyl]-L-tryptophyl- $\alpha$ -methyl-L-phenylalaninamide (11)

Prepared by the same method as 6,  $\alpha$ -methyl-L-phenylalanine was obtained by the method of Turk, et al (Turk, J., Panse, G. T., Marshall G. R., J. Org. Chem. 40:953 (1975)).

## EXAMPLE 13

30 N-[(1-Naphthalenylmethoxy)carbonyl]-L-tryptophyl- $\alpha$ -methyl-D-phenylalaninamide (12)

Prepared by the same method as 6. D- $\alpha$ -methyl-phenylalanine was obtained by the method of Turk, et al.

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## EXAMPLE 14

N-[[[4-(Propoxycarbonyl)phenyl]methoxycarbonyl]-L-tryptophyl- $\alpha$ -methyl-DL-phenylalaninamide (13)

5        Propyl 4-(hydroxymethyl)benzoate (0.10 g, 0.5 mmol), 4-nitrophenyl chloroformate (0.10 g, 0.5 mmol) and pyridine (0.04 mL, 0.5 mmol) were stirred for 18 hours in  $\text{CH}_2\text{Cl}_2$  (8 mL). The solvent was removed in vacuo and the white residue triturated with EtOAc and filtered. The filtrate was added to a  
10        solution of 5 (0.10 g, 0.27 mmol) and 1,1,3,3-tetramethylguanidine (0.10 mL, 0.81 mmol) in DMSO (2 mL) and stirred for 3.5 hours. The reaction mixture was poured onto  $\text{H}_2\text{O}$  and extracted with EtOAc. The  
15        organic layer was washed with 10% citric acid solution, saturated  $\text{NaHCO}_3$  solution,  $\text{H}_2\text{O}$ , and dried ( $\text{MgSO}_4$ ). Further purification by flash column chromatography on silica, eluting with  $\text{CH}_2\text{Cl}_2$  (95:5) gave 13 as a white foam (0.02 g, 13%); mp 78-105°C; MS (FAB) m/e 586 [M+H];  $^1\text{H}$  NMR (DMSO- $d_6$ )  $\delta$  0.97 (3H, t, J 7 Hz,  $\text{CH}_3\text{CH}_2$ ), 1.38 (0.5 x 3H, s,  $\alpha\text{-CH}_3$ ), 1.40 (0.5 x 3H, s,  $\alpha\text{-CH}_2$ ), 1.76 (2H, m,  $\text{CH}_2\text{CH}_2$ ), 2.80-3.45 (4H, m,  $\text{CH}_2\text{-indole}$ ,  $\text{CH}_2\text{Ph}$ ), 4.12-4.35 (3H, m, Trp  $\alpha\text{-H}$ ,  $\text{CH}_2\text{CH}_2\text{O}$ ), 4.94-5.15 (2H, m,  $\text{CH}_2\text{OCO}$ ), 6.95-7.95 (18H, m, Ar,  $\text{CONH}_2$ ,  $\text{CONH}$ ,  $\text{OCONH}$ , 10.82 (1H, s, indole NH); Anal. ( $\text{C}_{33}\text{H}_{36}\text{N}_4\text{O}_6 \cdot 0.75 \text{H}_2\text{O}$ ) C, H, N.  
25

## EXAMPLE 15

Boc( $\alpha$ -Me)-DL-PheODhbt (14)

30        1,3-Dicyclohexylcarbodiimide (4.95 g, 24 mmol) was added to a solution of 1 (6.70 g, 24 mmol) in THF (100 mL) at -15°C and allowed to stir for 5 minutes. 3-Hydroxy-1,2,3-benzotriazine-4-(3H)-one (3.91 g, 24 mmol) and an additional volume of THF (20 mL) were added and the mixture stirred at -10°C for 1 hour and  
35        at 0°C for 4 hours. After leaving overnight at 5°C a

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white solid precipitated. This was filtered and dried to give 14 (9.1 g, 89%):  $^1\text{H}$  NMR (DMSO- $d_6$ )  $\delta$  1.44 (3H, s,  $\alpha\text{-CH}_3$ ), 1.49 (9H, s, t-Bu), 3.06 (1H, d,  $J$  13 Hz,  $\text{CH}'\text{HPh}$ ), 3.61 (1H, d,  $J$  13 Hz,  $\text{CH}'\text{HPh}$ ), 7.15-7.38 (5H, m, Ph), 7.64 (1H, s, OCONH), 8.02 (1H, 5,  $J$  7.5 Hz, Ar), 8.19 (1H, t,  $J$  7.5 Hz, Ar), 8.33 (2H, d,  $J$  8 Hz, Ar).

## EXAMPLE 16

10 Boc-( $\alpha$ -Me)-DLPheGlyNH $_2$  (15)

14 (4.24 g, 10 mmol), glycineamide hydrochloride (1.11 g, 11 mmol), and triethylamine (1.39 mL, 11 mmol) in EtOAc (100 mL) were stirred overnight at room temperature. The white solid which precipitated was removed by filtration and washed with EtOAc. The filtrate was washed with 10% citric acid solution, saturated NaHCO $_3$  solution, H $_2$ O, and dried (MgSO $_4$ ). Removal of the solvent in vacuo gave 15 as a white solid (2.05 g, 61%):  $^1\text{H}$  NMR (DMSO- $d_6$ )  $\delta$  1.16 (3H, s,  $\alpha\text{-CH}_3$ ), 1.43 (9H, s, t-Bu), 2.95 (1H, d,  $J$  13 Hz, CH $_2$ Ph), 3.26 (1H, d,  $J$  15 Hz, CH $_2$ Ph), 3.46 (1H, br d,  $J$  16.5 Hz, NHCH $_2$ CO), 3.69 (1H, dd,  $J$  16.5 Hz, 6 Hz, NHCH $_2$ CO), 7.02-7.34 (8H, m, Ar, CONH $_2$ , OCONH), 8.17 (1H, bs, NHCO).

25

## EXAMPLE 17

( $\alpha$ -Me)-DLPheGlyNH $_2$  (16)

15 (2.0 g, 5.7 mmol) was stirred at 0°C in TFA (2 mL) for 15 minutes. The solvent was removed in vacuo and the residue triturated with ET $_2$ O. The white solid formed was filtered and dried to give 16 (1.97 g, 95%):  $^1\text{H}$  NMR (DMSO- $d_6$ )  $\delta$  1.52 (3H, s,  $\alpha\text{-CH}_3$ ), 3.06 (1H, d,  $J$  14 Hz, CH $_2$ Ph), 3.20 (1H, d,  $J$  14 Hz, CH $_2$ Ph), 3.74 (2H, d,  $J$  5.5 Hz, NHCH $_2$ CO),

30

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7.00-7.40 (7H, m,  $\text{Ph}_2\text{CONH}_2$ ), 8.09 (3H, bs,  $\text{NH}_3^+$ ),  
8.62 (1H,  $\underline{\text{J}}$  5.6 Hz, CONH).

## EXAMPLE 18

5 N-[(Phenylmethoxy)carbonyl]-L-tryptophyl- $\alpha$ -methyl-DL-phenylalanylglycinamide (17)

Hydrobenzotriazolyl tetramethyluronium  
hexachlorophosphate (HBTU) (0.19 g, 0.5 mmol) was  
added to a solution of Z-(L)-Trp (0.15 g, 0.5 mmol),  
10 16 (0.17 g, 0.5 mmol), and N,N-diisopropylethylamine  
(0.26 mL, 1.5 mmol) in DMF (3 mL) and stirred at room  
temperature for 45 minutes. Water was added and the  
mixture extracted with EtOAc. The organic layer was  
washed with 10% citric acid solution, saturated  
15  $\text{NaHCO}_3$  solution,  $\text{H}_2\text{O}$ , and dried ( $\text{MgSO}_4$ ). Further  
purification by flash column chromatography on  
silica, eluting with  $\text{CH}_2\text{Cl}_2$ :MeOH (90:10) gave 17 as a  
white foam (0.17 g, 61%); mp 92-110°C; MS (FAB) m/e  
556 [M+H];  $^1\text{H}$  NMR ( $\text{DMSO}-d_6$ )  $\delta$  1.19 (0.5 x 3H, s,  
20  $\alpha\text{-CH}_3$ ), 1.24 (0.5 x 3H, s,  $\alpha\text{-CH}_3$ ), 2.80-3.30 (4H, m,  
 $\text{CH}_2\text{-indole}$ ,  $\text{CH}_2\text{Ph}$ ), 3.40-3.78 (2H, m,  $\text{CH}_2\text{CONH}_2$ ),  
4.25-4.48 (1H, m, Trp- $\alpha\text{-H}$ ), 4.84-5.06 (2H, m,  
 $\text{CH}_2\text{OCO}$ ), 6.88-7.45 (16H, m, Ar, OCONH,  $\text{CONH}_2$ ),  
7.55-7.75 (2H, m, Ar), 7.80 (0.5 x H, t,  $\text{CONHCH}_2$ ),  
25 7.88 (0.5 x H, t,  $\text{CONHCH}_2$ ), 8.35 (0.5 x H, s,  
 $\text{NHC(CH}_3\text{)}$ ), 8.41 (0.5 x H, s,  $\text{NHC(CH}_3\text{)}$ ), 10.86 (1H, s,  
indole NH); Anal. ( $\text{C}_{31}\text{H}_{33}\text{N}_5\text{O}_{35} \cdot 0.5\text{H}_2\text{O}$ ) C, H, N.

## EXAMPLE 19

30 N-[(1-Naphthalenylmethoxy)carbonyl]-L-tryptophyl- $\alpha$ -methyl-DL-phenylalanylglycinamide (18)

Diisopropylethylamine (52  $\mu\text{L}$ , 0.3 mmol) was  
added to a stirred solution of N-[(1-naphthyl-  
methoxy)carbonyl]tryptophan (0.117 g, 0.3 mmol) and  
35 HBTU (0.114 g, 0.3 mmol) in DMF (5 mL) at room

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temperature. The mixture was stirred for 10 minutes, then 16 (0.105 g, 0.3 mmol) in DMF (5 mL) was added, followed by diisopropyl ethylamine (105  $\mu$ L, 0.6 mmol) and the reaction mixture stirred for a further  
5 18 hours. The mixture was poured into H<sub>2</sub>O (100 mL) and extracted with EtOAc (2 x 50 mL). The organic extracts were combined, washed with 10% citric acid solution (1 x 100 mL), saturated NaHCO<sub>3</sub> solution (1 x 100 mL), H<sub>2</sub>O (2 x 100 mL), and dried (MgSO<sub>4</sub>).  
10 The solvent was removed in vacuo and the residue purified by column chromatography on silica, eluting first with mixtures of EtOAc in hexane (30% to 70%) followed by CH<sub>2</sub>Cl<sub>2</sub>:MeOH (95:5) to give 18 as a white solid (0.148 g, 81%); MS (FAB) m/e 606 [M+H]: <sup>1</sup>H NMR (DMSO-d<sub>6</sub>)  $\delta$  1.21 (0.5 x 3H, s,  $\alpha$ -CH<sub>3</sub>), 1.26 (0.5 x 3H, s,  $\alpha$ -CH<sub>3</sub>), 2.85-3.78 (6H, m, CH<sub>2</sub>-indole, CH<sub>2</sub>Ph, CH<sub>2</sub>CONH<sub>2</sub>), 4.38 (1H, m, Trp  $\alpha$ -H), 5.44 (2H, m, CH<sub>2</sub> naphthyl), 6.92-7.20 (10H, m, Ar/NH), 7.33 (0.5 x H, s, Ar/NH), 7.35 (0.5 x H, s, Ar/NH),  
15 7.52-7.70 (6H, m, Ar/NH), 7.75-8.00 (4H, m, Ar/NH), 8.33 (0.5 x H, s, NH), 8.35 (0.5 x H, s, NH), 10.72 (1H, s, NH indole); Anal. (C<sub>35</sub>H<sub>35</sub>N<sub>5</sub>O<sub>5</sub>·0.5H<sub>2</sub>O) C, H, N.

## EXAMPLE 20

25 N-[(1-Naphthalenylmethoxy)carbonyl]-L-tryptophyl- $\alpha$ -methyl-L-phenylalanylglycinamide (19)

Prepared by the same method as Compound 18 as in Example 19 in methylphenylalanine and obtained by the method of Tuttle, et al.

30

## EXAMPLE 21

N-[(2,3-Dimethoxyphenyl)methoxy]carbonyl]-L-tryptophyl- $\alpha$ -methyl-DL-phenylalaninamide (20)

35 Prepared by the same method as Compound 6 in Example 7, white foam: mp 87-102°C; MS (FAB) m/e 559

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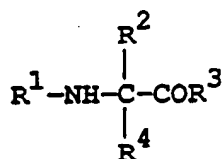
[M+H]<sup>+</sup>; <sup>1</sup>H NMR (DMSO-d<sub>6</sub>) δ 1.39 (3H, s, α-CH<sub>3</sub>), 2.88 (1H, t) and 3.11-3.39 (3H, m, CH<sub>2</sub>-indol, CH<sub>2</sub>Ph), 3.63 (3H, d, OCH<sub>3</sub>), 3.78 (3H, s, OCH<sub>3</sub>), 4.21 (1H, m, Trp α-H), 4.93 (2H, s, CH<sub>2</sub>O), 6.79-7.78 (17H, m, Ar, CONH<sub>2</sub>, CONH, OCONH), 10.76 (1H, s, indole NH), and (C<sub>31</sub>H<sub>34</sub>N<sub>4</sub>O<sub>6</sub>·0.5 H<sub>2</sub>O) C, H, N.



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## CLAIMS

1. A compound of formula



I

or a pharmaceutically acceptable salt thereof  
wherein:

$\text{R}^1$  is an N-terminal blocking group, from 0 to  
4 amino acid residues or hydrogen;

$\text{R}^2$  is a sidechain of a genetically coded amino  
acid except glycine;

$\text{R}^3$  is a C-terminal blocking group from 0 to  
4 amino acid residues,  $-\text{OH}$ , or  $\text{OR}^n$  wherein

$\text{R}^n$  is straight or branched alkyl or  
cycloalkyl of from 1 to 6 carbon atoms;

$\text{R}^4$  is a sidechain of a genetically coded amino  
acid, except glycine, or

$-\text{HC}=\text{CH}_2$ ,

$-\text{C}\equiv\text{CH}$ ,

$-\text{CH}_2-\text{CH}=\text{CH}_2$ ,

$-\text{CH}_2\text{C}\equiv\text{CH}$ ,

$-\text{CH}_2\text{Ar}$ ,

$-\text{CH}_2\text{OR}$ ,

$-\text{CH}_2\text{OAr}$ ,

$-(\text{CH}_2)_n\text{CO}_2\text{R}$ , or

$-(\text{CH}_2)_n\text{NR}^5\text{R}^6$  wherein n is an integer of  
from 0 to 3, R is hydrogen or lower

alkyl, Ar is a mono- or polycyclic

unsubstituted or substituted carbo- or  
heterocyclic aromatic or hydroaromatic  
moiety;

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$R^4$  and  $R^2$  cannot be hydrogen;  
 $R^1$  and  $R^3$  together cannot be more than 4  
amino acid residues.

35

2. A compound according to Claim 1 wherein:

$R^1$  is H,

Boc,

Fmoc,

5

Z,

1-Adoc,

2-Adoc,

IVA, or

NVA;

10

$R^2$  is  $\text{CH}_3-$  or

$\text{HOOC-CH}_2-$ ; and

$R^3$  is  $-\text{NH}_2$ ,

$-\text{OCH}_3$ , or

$-\text{OCH}_2\text{Ph}$ .

3. A compound according to Claim 1 selected from

MeLys-Trp-Asp-Asn-Gln,

Lys-MeTrp-Asp-Asn-Gln,

Lys-Trp-MeAsp-Asn-Gln,

5

Lys-Trp-Asp-MeAsn-Gln,

Lys-Trp-Asp-Asn-MeGln,

MeVal-Gly-His-Leu-Met- $\text{NH}_2$ ,

Val-Gly-MeHis-Leu-Met- $\text{NH}_2$ ,

Val-Gly-His-MeLeu-Met- $\text{NH}_2$ ,

10

Val-Gly-His-Leu-MeMet- $\text{NH}_2$ ,

MeGlp-His-Trp-Ser-Tyr,

Glp-MeHis-Trp-Ser-Tyr,

Glp-His-MeTrp-Ser-Tyr,

Glp-His-Trp-MeSer-Tyr,

15

Glp-His-Trp-Ser-MeTyr,

Gly-MeLeu-Arg-Pro-Gly- $\text{NH}_2$ ,

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Gly-Leu-MeArg-Pro-Gly-NH<sub>2</sub>,  
 Gly-Leu-Arg-MePro-Gly-NH<sub>2</sub>,  
 MeTyr-Pro-Ser-Lys-Pro,  
 20 Tyr-MePro-Ser-Lys-Pro,  
 Tyr-Pro-MeSer-Lys-Pro,  
 Tyr-Pro-Ser-MeLys-Pro,  
 Tyr-Pro-Ser-Lys-MePro,  
 MeThr-Arg-Gln-Arg-Tyr-NH<sub>2</sub>,  
 25 Thr-MeArg-Gln-Arg-Tyr-NH<sub>2</sub>,  
 Thr-Arg-MeGln-Arg-Tyr-NH<sub>2</sub>,  
 Thr-Arg-Gln-MeArg-Tyr-NH<sub>2</sub>,  
 Thr-Arg-Gln-Arg-MeTyr-NH<sub>2</sub>,  
 Gly-MeTrp-Thr-Leu-Asn,  
 30 Gly-Trp-MeThr-Leu-Asn,  
 Gly-Trp-Thr-MeLeu-Asn,  
 Gly-Trp-Thr-Leu-MeAsn,  
 MeLeu-Tyr-Gly-Leu-Ala-NH<sub>2</sub>,  
 Leu-MeTyr-Gly-Leu-Ala-NH<sub>2</sub>,  
 35 Leu-Tyr-Gly-MeLeu-Ala-NH<sub>2</sub>,  
 Leu-Tyr-Gly-Leu-Aib-NH<sub>2</sub>,  
 MePhe-Phe-Trp-Lys-Thr,  
 Phe-MePhe-Trp-Lys-Thr,  
 Phe-Phe-MeTrp-Lys-Thr,  
 40 Phe-Phe-Trp-MeLys-Thr,  
 Phe-Phe-Trp-Lys-MeThr,  
 MePhe-Phe-Gly-Leu-Met-NH<sub>2</sub>,  
 Phe-MePhe-Gly-Leu-Met-NH<sub>2</sub>,  
 Phe-Phe-Gly-MeLeu-Met-NH<sub>2</sub>, and  
 45 Phe-Phe-Gly-Leu-MaMet-NH<sub>2</sub>.

4. A compound named N-[α-methyl-N-[N-(N-L-tyrosylglycyl)glycyl]-L-phenylalanyl]-L-leucine trifluoroacetate (1:1 salt).

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5. A compound named N-[ $\alpha$ -methyl-N-[N-(N-L-tyrosylglycyl)glycyl]-D-phenylalanyl]-L-leucine trifluoroacetate (1:1 salt).
6. A compound named N-[[4-(chlorophenyl)methoxy]-carbonyl]-L-tryptophyl- $\alpha$ -methyl-DL-phenylalaninamide.
7. A compound named N-[[[4-(trifluoromethyl)-phenyl]methoxy]carbonyl]-L-tryptophyl- $\alpha$ -methyl-DL-phenylalaninamide.
8. A compound named N-[[[1,1'-biphenyl]-4-yl-methoxy]carbonyl]-L-tryptophyl- $\alpha$ -methyl-DL-phenylalaninamide.
9. A compound named N-[(9-anthracenylmethoxy)-carbonyl]-L-tryptophyl- $\alpha$ -methyl-DL-phenylalaninamide.
10. A compound named N-[(1-naphthalenylmethoxy)-carbonyl]-L-tryptophyl- $\alpha$ -methyl-DL-phenylalaninamide.
11. A compound named N-[(1-naphthalenylmethoxy)-carbonyl]-L-tryptophyl- $\alpha$ -methyl-L-phenylalaninamide.
12. A compound named N-[(1-naphthalenylmethoxy)-carbonyl]-L-tryptophyl- $\alpha$ -methyl-D-phenylalaninamide.
13. A compound named N-[[[4-(propoxycarbonyl)-phenyl]methoxy]carbonyl]-L-tryptophyl- $\alpha$ -methyl-DL-phenylalaninamide.

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14. A compound named N-[(phenylmethoxy)carbonyl]-L-tryptophyl- $\alpha$ -methyl-DL-phenylalanylglycinamide.
15. A compound named N-[(1-naphthalenylmethoxy)-carbonyl]-L-tryptophyl- $\alpha$ -methyl-DL-phenylalanylglycinamide.
16. A compound named N-[(1-naphthalenylmethoxy)-carbonyl]-L-tryptophyl- $\alpha$ -methyl-L-phenylalanylglycinamide.
17. A compound named N-[[ (2,3-dimethoxyphenyl)-methoxy]carbonyl]-L-tryptophyl- $\alpha$ -methyl-DL-phenylalaninamide.
18. A pharmaceutical composition comprising an amount of a compound according to Claim 1 effective to treat pain in a mammal suffering therefrom, and a pharmaceutically acceptable carrier.
19. A method of treating pain in a mammal comprising administering an effective pain treating amount of a compound according to Claim 1.